<u>Nonpoint Source Trade Crediting Calculations</u>

Finalized For Rahr Malting Permit On January 8, 1997

Introduction

The use of Best Management Practices (BMPs) to reduce nonpoint source pollution is included as an effluent limitation in the Rahr Malting Company's and National Pollutant Discharge Elimination System (NPDES) permit.

Rahr Malting has proposed to construct a new wastewater treatment facility (currently, Rahr's process water is treated at the Blue Lake facility). The proposed Rahr discharge is just upstream of river mile 25. In 1988, the MPCA and the US Environmental Protection Agency (EPA) established at a total maximum daily load (TMDL) for the Minnesota River below river mile 25. Allocation of load to point and nonpoint sources under the TMDL does not allow a re-allocation of load for Rahr's proposed discharge. As a result, Rahr Malting has proposed to combine at-plant effluent limits along with nonpoint source reductions to compensate for the load which will result from the proposed discharge.

Trading Framework

The trading concept is philosophically simple, yet the number of variables make the details of a trade complex. The focus of the Rahr trade is the reduction of oxygen demand in the TMDL zone of the river. In order to implement the point-nonpoint source (P-NPS) trades, the following definition of what constitutes a trade has been developed.

Trade: A "trade" is a direct reduction in NPS load which is applied against Rahr Malting's point source load. Trading parameters have been identified for phosphorus, nitrogen, five day carbonaceous biochemical oxygen demand ($CBOD_5$), and sediment. In order to address the relative persistence of these compounds in the river system and the spatial variability of BMP sites, NPS load reductions are converted to pollutant "units".

Trade Calculation

The "gold standard" for the Rahr trades is the presence of $CBOD_5$ load in the lower Minnesota River, where 1 pound per day (lb./day) of $CBOD_5$ in the TMDL zone equals 1 unit. Phosphorus, nitrogen, $CBOD_5$, and sediment from nonpoint sources all have varying degrees of persistence in the river system and mechanisms for exerting oxygen demand. The conversion of load reductions to trading units takes into account the relative persistence of the compound and the spatial variability of BMP sites. The pollutant equivalency credits are summarized in the table below and the $CBOD_5$ Percent Table.

Pollutant Equivalency Credits

Trade Parameter	Measured Value/Day	Metro Reach BMP $CBOD_5$ Credit	Upstream BMP $CBOD_5$ Credit
Phosphorus	1 pound	8 units	8 units
$CBOD_5$	1 pound	1 unit	see discussion below
Nitrogen	1 pound	4 units	1 unit
Sediment	1 ton	0.5 units	0.5 units

Phosphorus

The phosphorus to $CBOD_5$ crediting ratio will be 1:8 for the life of the BMP site. This is based on current estimates of the ratio at the City of Jordan, MN. The linkage connecting total phosphorus to $CBOD_5$ is algal growth and death cycles. The ratio increases upstream of Jordan, and the ecoregion mean estimates a value closer to 1:17. As the Minnesota River is cleaned up and light penetrates further into the water column, the actual ratio should move toward the ecoregion values.

$CBOD_5$

Exertion of oxygen demand within the river system from NPS $CBOD_5$ loading is highly variable depending on the location of the NPS loading, the river flow, and velocity. Within the TMDL zone, 1 pound of Carbonaceous Biochemical Oxygen Demand as determined by the five day test ($CBOD_5$) will be credited at 1 unit. A "$CBOD_5$ trading zone" which extends upstream from the TMDL to river mile 107, or equivalent tributary distances, has been established based on the exertion of $CBOD_5$ oxygen demand during the 7-day 10-year low flow (7Q10). Upstream of the "$CBOD_5$ trading zone" one percent of the reduction will be credited for $CBOD_5$ reductions since most of this oxygen demand will have already been exerted prior to the TMDL zone during low flow periods. The $CBOD_5$ Percent Credit Table determines the calculated percent remaining $CBOD_5$ credits for the basin site locations.

$CBOD_5$ Percent Credit Table

River Mile	$CBOD_5$ Percent Remainin	Miles From Shakopee
25	100%	0
26	96%	1
27	93%	2
28	91%	3
29	89%	4
30	86%	5
31	84%	6
32	82%	7
33	80%	8
34	77%	9
35	75%	10
36	73%	11
37	71%	12
38	70%	13
39	68%	14
40	66%	15
41	64%	16
42	62%	17
43	61%	18
44	59%	19
45	58%	20
46	56%	21
47	55%	22
48	53%	23
49	52%	24
50	50%	25
51	49%	26
52	48%	27
53	46%	28
54	45%	29
55	44%	30
56	43%	31
57	42%	32
58	41%	33
59	40%	34
60	38%	35
61	37%	36
62	36%	37
63	35%	38
64	35%	39
65	34%	40
66	33%	41
67	32%	42
68	31%	43
69	30%	44

River Mile	$CBOD_5$ Percent Remaining	Miles From Shakopee
70	29%	45
71	29%	46
72	28%	47
73	27%	48
74	26%	49
75	26%	50
76	25%	51
77	24%	52
78	24%	53
79	23%	54
80	22%	55
81	22%	56
82	21%	57
83	21%	58
84	20%	59
85	20%	60
86	19%	61
87	19%	62
88	18%	63
89	18%	64
90	17%	65
91	17%	66
92	16%	67
93	16%	68
94	15%	69
95	15%	70
96	15%	71
97	14%	72
98	14%	73
99	13%	74
100	13%	75
101	13%	76
102	12%	77
103	12%	78
104	12%	79
105	11%	80
106	11%	81
107	11%	82
>107	1%	>82

Nitrogen

The protection of drinking water, the Gulf of Mexico hypoxia issue, nitrogen's eutrophication links, and direct demand of ammonia on oxygen are all considered to benefit from nitrogen trading. Nitrogen is assimilated, where it creates eutrophic conditions in a more complex interaction than phosphorus. The maximum credit ratio for nitrogen is 1:4 in the TMDL zone. The actual oxygen demand associated with the nitrogen loading is 4.6 pounds of oxygen per pound of Total Kjeldahl Nitrogen (TKN). Calculation of load reductions from livestock management BMPs will include a 50% "field loss factor" to account for atmospheric nitrogen losses prior to transport into the water column.

Sediment

Only minor crediting values are directly assigned to sediment. Control of sediment losses from BMP sites will result in reductions in turbidity and oxygen demand associated with sediments.

NPDES Permit Loads

The Rahr Malting permit will allow the discharge of up to 150 lb./day of $CBOD_5$ just upstream of the TMDL zone. This $CBOD_5$ is assumed to be carried intact into the TMDL zone, requiring that 150 units, or 54,750 units per year (units/year) to be addressed through point-nonpoint source trading.

As part of the NPDES permit, Rahr has agreed to an effluent phosphorus limit of 2 mg/l instead of the 3 mg/l limit MPCA would otherwise propose at this time. Due to this, a 30 unit credit may be applied to the cumulative load reduction during the year 2001 and subsequent years provided the Permittee's phosphorus limit remains 2 mg/l or less. In addition, up to 10 units of the phosphorus credit may be used in either 1998, 1999 or 2000 for permit compliance purposes to satisfy any shortfall in that year's nonpoint source load reduction requirement. As basin wide NPDES phosphorus reductions are implemented by the MPCA, the relative benefits of the Rahr phosphorus limit will decrease. Therefore, it is likely that the trading credit for the effluent phosphorus limit will be terminated in a future permit cycle.

The Permittee has accepted a year round $CBOD_5$ limit of 12 mg/l instead of the limit MPCA would otherwise propose at this time of 12 mg/l $CBOD_5$ from June through September and 25 mg/l $CBOD_5$ from October through May. Due to this, a 30 unit credit may be applied to the cumulative value for the year 2001 and subsequent years provided the Permittee's year round $CBOD_5$ limit remains 12 mg/l or less.

The trading credit units required for Rahr Malting are summarized in the table below.

Trading Units Required

Trading Criteria	Daily Equivalent	Annual Equivalent
NPDES Permitted Discharge Load	150 units	54,750 units/year
Direct NPS Trading	90 - 150 units	32,850 - 54,750 units/year
Effluent Phosphorus Credit (as needed)	30 units	10,950 units/year
Effluent $CBOD_5$ Credit (as needed)	30 units	10,950 units/year

Assumptions

The P-NPS trade proposal assumes many physical process restraints. The following is a list of conditions which selection of BMPs are based on:

1. The Best Management Practice (BMP) must occur upstream of the Rahr discharge point in the Minnesota River basin.

2. The Phosphorus unit value is based on phosphorus conversion to chlorophyll and the chlorophyll death and decay resulting in a $CBOD_5$ load on the river.

3. Phosphorus will be treated as a conservative and persistent compound. The phosphorus entering the watershed at any location will cycle down stream and exert a load on the lower reach of the Minnesota River at some future date.

4. The Midwest Plan Service publication, which provides the manure estimates, reflects the current professional estimates of manure content for the parameters of $CBOD_5$, phosphorus and nitrogen.

5. The Universal Soil Loss Equation (USLE) and later the Revised Soil Loss Equation (RSLE) reflect the current professional expertise for projecting soil erosion rates from sheet, rill and ephemeral gullies. Local Natural Resource Conservation Service (NRCS) and Soil and Water Conservation Service (SWCD) will determine the equation coefficients for sites in their respective areas.

6. Delivery ratios of sediment and phosphorus contents of soils are based on conservative professional estimates unless justification of higher rates can be provided.

7. As with any estimation process using average or conservative numbers, the use of several sites increases the probability that the averages or conservative estimates are reflective of the sites in the whole base. When using several sites the variance of a specific site below the estimated average value is accounted for by the excess of a different site in the population. The system developed has a overall safety factor of

approximately two worked in to the conservative estimating process. Therefore, the administration for rigorous inspection and enforcement of BMP sites will be avoided and replaced by initial inspections and periodic checks.

8. The choices of average or conservative values is constantly improving as the knowledge base on the nonpoint sciences improve and the number of research sites increase. As documentation increases and modifications to the following calculations are justified this document may be updated to remain current. Previously approved trades will remain credited at the values previously agreed to; modifications will only apply to trade sites yet to be approved by the MPCA through permit modification.

9. The phosphorus to $CBOD_5$ trading ratio will be 1:8 for the life of the BMP site. This is based on current estimates of the ratio at the city of Jordan. The ratio increases above the Minnesota River at Jordan, the ecoregion mean estimates a value closer to a 1:17 ratio for phosphorus to $CBOD_5$ correlation. As the Minnesota River is cleaned up the ratio will move toward the ecoregion values. This trend provides a portion of the conservative estimation that is desirable in trading versus command and control regulation.

10. Nitrogen will be considered as a trade parameter. The protection of drinking water, the Gulf of Mexico hypoxia issue, nitrogen's eutrophication links and ammonia's direct demand on oxygen are all considered valuable objectives for this allowance. Nitrogen is assimilated, however, it creates eutrophic conditions in a more complex interaction cycle than phosphorus. Therefore, trading credits for nitrogen will be given after factoring in a 50 percent decay rate prior to loading the surface water and the nutrient will not be treated as a persistent or given constant rate in the pollutant crediting units.

11. The term "surface water entry points" will be defined as streams, rivers, wetlands, ditches and surface tile intakes which are connected to the main stem of the Minnesota River. The connection may be at some point down stream. Watersheds entering lakes have a greater assimilative capacity and therefore must be justified prior to use in this agreement.

12. Land locked areas, and watershed divides within a larger BMP implementation site will be factored out of all pollutant reduction calculations by estimating only contributing acres associated with the Minnesota River.

BMP Calculation Procedures

Four general categories of BMPs have been identified for P-NPS trading:

1. <u>**Soil Erosion BMPs**</u>, including sheet, rill and ephemeral gully erosion, gully erosion, stream, river, and ditch bank erosion.

2. **Livestock Exclusion,** separating livestock from waterways for protection against bank erosion and direct manure impacts.
3. **Rotational Grazing With Livestock Exclusion,** to enhance forages for pollutant reductions from filtering processes and plant nutrient uptake.
4. **Critical Area Set Aside,** of highly erodible land.
5. **Wetland Treatment Systems**, for nutrient removal.

As trading practices become adopted on a more widespread basis, it is likely that additional BMP categories will be identified. These additional BMP categories can be added to the list during permit reissuance or a permit modification.

The variety of BMPs which can be implemented all contain aspects of their establishment or performance which require special considerations by the operator. Some the changes will be new to the operator and technical assistance will be required as part of the BMP set up (i.e., rotational grazing of livestock may bring forage questions to bear and technical assistance through the establishment period will be provided). All BMPs with vegetative components will require an establishment criteria to ensure a dense stand. In addition some BMPs which treat sediment by filtering or settling require on going maintenance:

- to ensure sheet flow conditions are maintained in upland flow areas,
- to remove sediment build ups which obstruct the operation of the BMP,
- to reestablish a structure or plant life after major storm events or fire,
- to remove harmful infestations (such as, carp from treatment wetlands, destructive insects in vegetation and beavers from bioengineering sites)

At the time of the site crediting and approval the responsibilities and technical assistance proposed to address the above issues for the site will be considered.

Soil Erosion BMPs

The following steps outline a general process for calculating estimates of pollutant reductions from soil erosion BMPs.

Step 1: Calculate reduction in soil erosion. Based on the erosion mechanism, different methods of estimating the erosion rate apply.

Sheet, Rill and Ephemeral Gully Erosion:

A. Estimate the site erosion rate prior to and after installing the BMP using the USLE or RSLE. (Determination of which process used will reflect the equation used by the local NRCS or SWCD). Result will be in tons/acre/year (SED_p and SED_a).

B. Using the Delivery Ratio Table below enter the sheet and rill erosion category to calculate the percentage delivered for the prior and after values. Sediment reduction in tons equals the difference between these values times the acres that the practice was applied over. SEDRDC = $(SED_p * DR) - (SED_a * DR)$

C. To determine the nutrient mass reduced, take the sediment tons per acre prior and after (from B; $SED_p * DR$ & $SED_a * DR$) and enter the Enrichment Table. Nutrient enrichment estimates represent the nutrient attachment potential of different soil types combined with the settling characteristics of the different particles. For example in a sandy clay, sand holds less phosphorus and settles out sooner than clay, so as a mixed soil is transported, the sands drop out and the clay fractions can continue. Thus, the portion delivered represents more of the clays and less of the sands instead of the original sand clay mix. To estimate the enrichment take the nutrient content results (either nitrogen or phosphorus) for the "prior estimate" and subtract the "after estimate" value from the table. (P_p, P_a, N_p and N_a), PRDC = $P_p - P_a$ and NRDC = $N_p - N_a$

Delivery Ratios

Area	Gully Erosion Channelized to Water	Gully Erosion Nonchannelized to Water	Sheet, Rill Erosion	Stream Bank Erosio
Riparian	100%	NA	100% When Justified	100%
Within 1/4 Mile of Stream	100%	20%	20%	NA
Greater than 1/4 Mile from Stream	50%	10%	10%	NA

Sediment Delivery Rate T/AC/YR	Phosphorus Enrichment Estimate	units	lbs/ac		Nitrogen Enrichment Estimate	units lbs/ac		
	Clay	Silt	Sand	Peat	Clay	Silt	Sand	Peat
0.01	0.05	0.04	0.03	0.06	0.09	0.08	0.07	0.12
0.02	0.08	0.07	0.06	0.10	0.16	0.14	0.12	0.21
0.03	0.11	0.10	0.08	0.15	0.22	0.19	0.16	0.29
0.04	0.14	0.12	0.10	0.18	0.28	0.24	0.21	0.37
0.05	0.17	0.15	0.12	0.22	0.33	0.29	0.25	0.44
0.06	0.19	0.17	0.14	0.25	0.39	0.34	0.29	0.51
0.07	0.22	0.19	0.16	0.29	0.44	0.38	0.32	0.57
0.08	0.24	0.21	0.18	0.32	0.49	0.42	0.36	0.64
0.09	0.27	0.23	0.20	0.35	0.54	0.47	0.40	0.70
0.1	0.29	0.25	0.22	0.38	0.58	0.51	0.43	0.76
0.2	0.51	0.44	0.38	0.66	1.0	0.9	0.8	1.3
0.3	0.70	0.61	0.52	0.92	1.4	1.2	1.0	1.8
0.4	0.88	0.77	0.65	1.15	1.8	1.5	1.3	2.3
0.5	1.1	0.9	0.8	1.4	2.1	1.8	1.6	2.8
0.6	1.2	1.1	0.9	1.6	2.4	2.1	1.8	3.2
0.7	1.4	1.2	1.0	1.8	2.8	2.4	2.0	3.6
0.8	1.5	1.3	1.1	2.0	3.1	2.7	2.3	4.0
0.9	1.7	1.5	1.2	2.2	3.4	2.9	2.5	4.4
1	1.8	1.6	1.4	2.4	3.7	3.2	2.7	4.8
2	3.2	2.8	2.4	4.2	6.4	5.6	4.7	8.4
3	4.4	3.9	3.3	5.8	8.9	7.7	6.5	11.6
4	5.6	4.8	4.1	7.3	11.1	9.7	8.2	14.5
5	6.7	5.8	4.9	8.7	13.3	11.6	9.8	17.4
6	7.7	6.7	5.7	10.1	15.4	13.4	11.4	20.1
7	8.7	7.6	6.4	11.4	17.4	15.2	12.9	22.8
8	9.7	8.4	7.2	12.7	19.4	16.9	14.3	25.3
9	10.7	9.3	7.9	13.9	21.3	18.5	15.8	27.8
10	11.6	10.1	8.6	15.1	23.2	20.2	17.1	30.3
11	12.5	10.9	9.3	16.3	25.0	21.8	18.5	32.7
12	13.4	11.7	9.9	17.5	26.8	23.3	19.8	35.0
13	14.3	12.4	10.6	18.7	28.6	24.9	21.2	37.3
14	15.2	13.2	11.2	19.8	30.4	26.4	22.4	39.6
15	16.0	14.0	11.9	20.9	32.1	27.9	23.7	41.9
16	16.9	14.7	12.5	22.0	33.8	29.4	25.0	44.1
17	17.7	15.4	13.1	23.1	35.5	30.8	26.2	46.3
18	18.6	16.1	13.7	24.2	37.1	32.3	27.4	48.4
19	19.4	16.9	14.3	25.3	38.8	33.7	28.7	50.6
20	20.2	17.6	14.9	26.3	40.4	35.1	29.9	52.7
21	21.0	18.3	15.5	27.4	42.0	36.5	31.0	54.8
22	21.8	19.0	16.1	28.4	43.6	37.9	32.2	56.9
23	22.6	19.6	16.7	29.5	45.2	39.3	33.4	58.9
24	23.4	20.3	17.3	30.5	46.7	40.6	34.5	61.0
25	24.1	21.0	17.8	31.5	48.3	42.0	35.7	63.0
26	24.9	21.7	18.4	32.5	49.8	43.3	36.8	65.0
27	25.7	22.3	19.0	33.5	51.4	44.7	38.0	67.0
28	26.4	23.0	19.5	34.5	52.9	46.0	39.1	69.0
29	27.2	23.6	20.1	35.5	54.4	47.3	40.2	70.9
30	27.9	24.3	20.7	36.4	55.9	48.6	41.3	72.9

Stream Bank and Gully Erosion:

A. Using the existing contours, estimate the volume of soil removed by gully erosion and/or stream bank erosion. (VOL)

B. Using the land operator as a reference determine the amount of time in years it has taken to produce the gully and/or stream bank erosion. (VOL/YRs)

C. Using the soil density values shown below, convert the volume per year estimate to tons/year. (SED)

Soil Textural Class	**Dry Density Tons/ft^3**	**Dry Density lbs./ ft^3**
Sands, loamy sands	0.055	110
Sandy loam	0.0525	105
Fine sandy loam	0.05	100
Loams, sandy clay loams, sandy clay	0.045	90
Silt Loam	0.0425	85
Silty clay loam, silty clay	0.04	80
Clay loam	0.0375	75
Clay	0.035	70
Organic	0.011	22

Step 2: Determine amount of sediment delivered to the river system. Using the Delivery Ratio table above, select the appropriate delivery ratio (DR). Multiply the soil erosion rate (SED in tons/year) by the delivery ratio to determine the amount of soil reaching the river. Result will be in tons/year delivered. DEL = SED * DR

Step 3: Determine NPS pollutant values associated with sediment. Using the default values in the table below, calculate the amount of phosphorus and nitrogen delivered to the river system. (PDEL, NDEL), PDEL = DEL * Adjustment Coefficient for P,
NDEL = DEL * Adjustment Coefficient for N,

Soil Type	Phosphorus Adjustment Correction Factor	Nitrogen Adjustment Correction Factor
Sand	0.85 lb./ton	1.7 lb./ton
Silt	1.00 lb./ton	2.00 lb./ton
Clay	1.15 lb./ton	2.30 lb./ton
Peat	1.50 lb./ton	3.00 lb./ton

The values listed above are conservative estimates. At certain BMP sites, soils may have enriched nutrient content due to past application of fertilizers. Higher nutrient levels can be justified through site-specific soil sampling. However, to account for uncertainties associated with the sampling process, site specific values shall be multiplied by a safety factor of 75% to calculate the amount of nutrients actually delivered.

$CBOD_5$ content of sediments is expected to vary widely with the amount of organic matter present. Transport, organic matter present, and time of year all present variation of estimated values. Unless other wise justified and preapproved the crediting estimation of the $CBOD_5$ content and turbidity impacts reduced will be 0.5 lbs per ton of soil as stated in the trading credit table.

Step 4: Calculate Trading Credits. Using the unit conversion ratios from the trading credit table, calculate the credit units that will result from the estimated reductions in phosphorus, nitrogen, $CBOD_5$, and sediment.

Livestock Exclusion

The following steps outline a general process for calculating estimates of pollutant reductions from livestock exclusion.

Livestock exclusion: Livestock exclusion for the purpose of this discussion means a management contract such as fencing and alternative water supply which provides a separation distance protecting the water and bank/shoreline.

Step 1: Determine the number of head and size of animals. This information can be obtained from the livestock manager. In Minnesota, the maximum grazing density for cattle that can be supported without supplemental feeding is 1 animal per acre (head/ac) over a 5-month grazing season for cattle. Other animal pasture operations must determine the land's capacity and document the assumptions. The animal count will be determined by the typical weight categories given in the Midwest Plan Service's

Livestock Waste Facilities Handbook (MWPS-18). Keep separate counts for each animal category presented. (HEAD)

Step 2: Determine the manure load generated by the herd. The Midwest Plan Service's Livestock Waste Facilities Handbook (MWPS-18) lists standard production rates for nitrogen, phosphorus, and $CBOD_5$. (MBOD, MP, MN)

MBOD = HEAD * MWPS-18 $CBOD_5$

MP = HEAD * MWPS-18 P

MN = HEAD * MWPS-18 N

MTBOD = $CBOD_5$ from all the animal categories presented

MTP = Phosphorus from all the animal categories presented

MTN = Nitrogen from all the animal categories presented

Step 3: Determine the field layout currently and after rotational grazing with livestock exclusion has been implemented. Generally, the pasture area can be divided into a riparian zone and an upland area. For large pastures, the upland area may be divided based on the delivery ratio as shown below:

Area	Delivery Ratio
Riparian	100%
Upland (within 1/4 mile of stream)	20%

Step 4: Determine the amount of nitrogen, phosphorus, and $CBOD_5$ delivered in each portion of the pasture before and after implementation of the BMP. Deposition of manure in pasture areas is assumed to be directly proportional to the amount of time spent by the animals in each area. Research into the amount of time unrestricted cattle will spend in the riparian zone is limited and is strongly influenced by regional climatic and forage factors. After a review of existing research data, the MPCA has proposed the following time distribution for beef cattle having unrestricted access in the riparian zone:

Month	Time in Riparian Zone
May	25%
June	25%
July 0-15	25%
July 15-30	36%
August	36%
September	25%
Average	*28%*

Time not spent in the riparian zone is assumed to be spread equally throughout the upland pasture area.

Example time distribution (TD) are shown below:

Example Time Distributions

	Livestock Management	
Pasture Area	Before BMP	After BMP
Riparian	28%	0%
Upland (within 1/4 mile)	72%	100%

The amount of nitrogen, phosphorus, and $CBOD_5$ deposited in each portion of the pasture can be calculated based on the amount of time spent in each pasture area. Field or Paddock account variables should be kept separate based on proximity to receiving water.

Step 5: Determine amount of nitrogen, phosphorus, and $CBOD_5$ delivered to the river system.

In general, the amount of nitrogen, phosphorus, and $CBOD_5$ delivered can be calculated from the amount deposited in each pasture area multiplied by that area's delivery ratio. However, several special conditions apply:

Herd Size: As mentioned in Step 1, the maximum grazing density for beef cattle is 1 head/ac without supplemental feeding. If a substantial portion of the pasture will fall under a conservation easement, the herd size should be reduced in the calculations to reflect the decreased carrying capacity after BMP implementation.

Nitrogen: After manure deposition in the pasture, some nitrogen will be lost to the atmosphere through ammonia volatilization. The amount lost is weather-dependent. In order to account for in-field losses of nitrogen prior to transport, nitrogen loadings should be multiplied by a "field loss factor" of 50%.

Filter Strip: Filter strip credit will be allowed for management areas where flow characteristics and vegetation are such that filtering out of solids is enhanced. The minimum width of the easement for application of a filter strip function is 25 feet for stem grass vegetation, and 50 feet for woody vegetation. Filter strips are assumed to remove 30% of particulate pollutants and 0% of soluble pollutants. The relative distribution of soluble/particulate fractions is assumed to be 50%/50% for manure-based nitrogen, phosphorus, and $CBOD_5$.

Step 6: Calculate Trading Credits. Using the unit conversion ratios from the trading credit table, calculate the credit units that will result from the estimated reductions in phosphorus, nitrogen, $CBOD_5$, and sediment.

Rotational Grazing With Livestock Exclusion

The following steps outline a general process for calculating estimates of pollutant reductions from rotational grazing when added to livestock exclusion.

Step 1: Determine the number of head and size of animals. This information can be obtained from the livestock manager. In Minnesota, the maximum grazing density for cattle that can be supported without supplemental feeding is 1 animal per acre (head/ac) over a 5-month grazing season for cattle. Other animal pasture operations must determine the land's capacity and document the assumptions. The animal count will be determined by the typical weight categories given in the Midwest Plan Service's Livestock Waste Facilities Handbook (MWPS-18). Keep separate counts for each animal category presented. (HEAD)

Step 2: Determine the manure load generated by the herd. The Midwest Plan Service's Livestock Waste Facilities Handbook (MWPS-18) lists standard production rates for nitrogen, phosphorus, and $CBOD_5$. (MBOD, MP, MN)
MBOD = HEAD * MWPS-18 $CBOD_5$
MP = HEAD * MWPS-18 P
MN = HEAD * MWPS-18 N
MTBOD = $CBOD_5$ from all the animal categories presented
MTP = Phosphorus from all the animal categories presented
MTN = Nitrogen from all the animal categories presented

Step 3: Determine the field layout currently and after rotational grazing with livestock exclusion has been implemented. Generally, the pasture area can be divided into a riparian zone and an upland area. For large pastures, the upland area may be divided based on the delivery ratio as shown below:

Area	Delivery Ratio
Riparian	100%
Upland (within 1/4 mile of stream)	20%
Upland (greater than 1/4 mile from stream)	10%

Step 4: Determine the amount of nitrogen, phosphorus, and $CBOD_5$ delivered in each portion of the pasture before and after implementation of the BMP. Deposition of manure in pasture areas is assumed to be directly proportional to the amount of time spent by the animals in each area. Research into the amount of time unrestricted cattle will spend in the riparian zone is limited and is strongly influenced by regional climatic and forage factors. After a review of existing research data, the MPCA has proposed the following time distribution for beef cattle having unrestricted access in the riparian zone:

Month	Time in Riparian Zone
May	25%
June	25%
July 0-15	25%
July 15-30	36%
August	36%
September	25%
Average	*28%*

Time not spent in the riparian zone is assumed to be spread equally throughout the upland pasture area.

Example time distribution (TD) are shown below:

Example Time Distributions

	Livestock Management	
Pasture Area	Before BMP	After BMP
Riparian	28%	0%
Upland (within 1/4 mile	36%	50%
Upland (greater than 1/4 mile)	36%	50%

The amount of nitrogen, phosphorus, and $CBOD_5$ deposited in each portion of the pasture can be calculated based on the amount of time spent in each pasture area. Field or Paddock account variables should be kept separate based on proximity to receiving water.

Step 5: Determine amount of nitrogen, phosphorus, and $CBOD_5$ delivered to the river system.

In general, the amount of nitrogen, phosphorus, and $CBOD_5$ delivered can be calculated from the amount deposited in each pasture area multiplied by that area's delivery ratio. However, several special conditions apply:

Herd Size: As mentioned in Step 1, the maximum grazing density for beef cattle is 1 head/ac without supplemental feeding. If a substantial portion of the pasture will fall under a conservation easement, the herd size should be reduced in the calculations to reflect the decreased carrying capacity after BMP implementation.

Nitrogen: After manure deposition in the pasture, some nitrogen will be lost to the atmosphere through ammonia volatilization. The amount lost is weather-dependent. In order to account for in-field losses of nitrogen prior to transport, nitrogen loadings should be multiplied by a "field loss factor" of 50%.

Filter Strip: Filter strip credit will be allowed for management areas where flow characteristics and vegetation are such that filtering out of solids is enhanced. The minimum width of the easement for application of a filter strip function is 25 feet for stem grass vegetation, and 50 feet for woody vegetation. Filter strips are assumed to remove 30% of particulate pollutants and 0% of soluble pollutants. The relative distribution of soluble/particulate fractions is assumed to be 50%/50% for manure-based nitrogen, phosphorus, and $CBOD_5$.

Step 6: Calculate Trading Credits. Using the unit conversion ratios from the trading credit table, calculate the credit units that will result from the estimated reductions in phosphorus, nitrogen, $CBOD_5$, and sediment.

<u>Critical Area Set-Aside</u>

Many areas in the Minnesota River floodplain are still in row crop production. An example of scour erosion rates on cropland fields within the floodplain is 75 tons/ac/year, and that establishing a good permanent vegetative cover would reduce this to 3 tons/ac/year (Scott County SWCD), if a woody vegetative cover is placed with some structural BMPs in the channel the scour situation can be altered to one of deposition. Placing these areas under conservation easement and/or adding bio-engineering would result in substantial NPS reductions.

<u>River Flood Scoured Areas</u>

Step 1: Determine portion of field subject to scour excavation. This information can be obtained through the land owner or by direct observation of field conditions. The erosion volumes also must be estimated by averaging the previous events in a tons/acre unit base. (AREA, VOL)

Step 2: Using the dry density table, provide above, calculate the weight of the soil eroded by multiplying the dry density and the volume. (Tons/acre)

Step 3: Determine frequency of flooding. This can be determined from the landowner or through flood insurance maps. (FREQ)

Step 4: Determine average annual sediment loading. This is determined by multiplying the scour area by the averaged volume and dividing the by the flooding frequency.

SED = tons/acre/yr = AREA * VOL / FREQ

Step 5: Determine NPS pollutant values associated with sediment. . Assuming 100 percent delivery and using the default values in the table below, calculate the amount of phosphorus and nitrogen delivered to the river system.

Soil Type	Phosphorus Content	Nitrogen Content
Sand	0.85 lb./ton	1.70 lb./ton
Silt	1.00 lb./ton	2.00 lb./ton
Clay	1.15 lb./ton	2.30 lb./ton
Peat	1.50 lb./ton	3.00 lb./ton

The values listed above are conservative estimates. At certain BMP sites, soils may have enriched nutrient content due to past application of chemical fertilizers. Higher nutrient levels can be justified through site-specific soil sampling. However, to account for uncertainties associated with the sampling process, site specific values shall be multiplied by a safety factor of 75% to calculate the amount of nutrients actually delivered.

$CBOD_5$ content of sediments is expected to vary widely with the amount of organic matter present. Calculation of the $CBOD_5$ content will be done based on site-specific sampling using the 75% safety factor.

Step 5: Calculate Trading Credits. Using the unit conversion ratios from the trading credit table, calculate the credit units that will result from the estimated reductions in phosphorus, nitrogen, $CBOD_5$, and sediment.

Bluffs and Restored Wetlands

These types of critical area set asides will follow the Sheet, Rill and Ephemeral Gully Erosion system calculations as stated above. Consideration of the following two aspects of this category should be provided in addition to the estimation equations:

- Restored wetland contributing area will depend on determination that the wetland remains hydraulically unconnected with the watershed previously drained to. However, treatment credit can be justified by following the conditions of the treatment wetland systems section.

- Steep bluffs or hill slopes need may need several practices to obtain stability of the soils during their installation and through out the trade life.

Wetland Treatment Systems

The construction of wetland treatment systems specifically for water quality enhancement defines the wetland treatment system nonpoint source trading BMPs. Wetlands are a valuable watershed management tool in any basin. Wetlands help stabilized hydraulic peaks, provide necessary habitat for the many species critical to the food chain and settle sediments out of the runoff. However, not all wetlands remove nutrient loading from the watershed. Some wetlands act as sinks for phosphorus much of the year only to pulse the mass of nutrients stored out during stressful times such as after drought periods or snow melt. The constructed wetland treatment system is designed to control the way the nutrients are captured and stored or converted so that the mass of nutrients are not available to be released downstream. By maximizing optimum depths, surface area and detention time criteria nitrogen is volatilized off to the atmosphere while the phosphorus is captured and buried. This type of wetland may limit some types of habitat use but is targeted specifically for chemical and sediment treatment.

The science of nutrient treatment by wetlands is relatively new to the design processes in colder climates. Mixed results have often been obtained. Excellent results have been obtained by a system on the Des Plaines River near Chicago, Illinois. The basic concepts designed for with this constructed wetland provide controlled depths ranges to prevent resuspension of sediments, prevention of short circuiting of flows and adequate detention times which all provide for the loading rates for settling characteristics. When following these basic guidelines the performance equation for predicting phosphorus is:

$$\ln\left[\frac{C_o}{C_i}\right] = \frac{-k}{q}$$

where:

C_o = outlet mean annual phosphorus concentration in mg/l
C_i = inlet mean annual phosphorus concentration in mg/l
k = 1st order rate constant set at
12.1 meters depth per year for non-research projects
23.7 meters depth per year when research is provided (for first three research projects); or
Average of Research Results, upon completion of first three research projects
q = loading rate in meters of depth per year

Sediment reduction credits will be based on the annual average water concentration of sediment for the treated stream reduced by 75 percent. The volume treated will be estimated by design flows based on the average year's cycle as determined by flow data (if available) at the location.

Nitrogen reduction credits will be allowed based on the specific site information provided in the final site design. The crediting reduction rate will be determined by the streams content of nitrogen, flow and detention design aspects of the treatment wetland and a conservative factor of 25 percent less than comparable site designs at other locations. The literature sites from the other locations will be used only if it can be verified that the site has relatively the same design characteristics and flow and loading constraints. As the information on this process is developing a formula for projection of the credits will be developed and approved by the Permittee representatives and the MPCA staff.

Wetland Research will be targeted at assessing the performance of wetland treatment sites in Minnesota. The research can be provide by another partner or non-trade participant. Constructed wetland treatment systems will use the following guidelines for planning considerations, as adapted from Robert Pitt, November 2, 1993:

1. Treatment systems can have poor water quality and water contact recreation and consumptive fishing should be discouraged.

2. Keep the wetland shape simple to encourage good water circulation. The length should be about three to five times the width for maximum detention efficiency and the inlets and outlets need to be widely spaced to minimize short-circuiting. Lower length to width ratios will be allowed if justification can be provided based on the design flows, vegetation establishment and/or energy of the unchannelized water in the wetland.

3. Protect the inlet and outlet areas from scour erosion.

4. Minimum and maximum depths of the wetland need to be considered. The depth should not be such that anoxic layers readily develop. Nor should the bounce of the wetland be too high.

5. Maximum flows to be treated will be designed for by providing adequate detention times and emergency spillway or flow bypasses. These design aspects can be met in many varying alternatives. However, the main planning consideration driving a treatment wetland is the capture and long term storage of the sediment and nutrients. The approved system will strongly address these issues in the site design.

6. A routine maintenance schedule will be developed, which will address:
    - the sediment accumulation
    - provisions for unforeseen circumstances (such as carp resuspending the sediments)
    - the inspection and replacement of structures
    - establishment and maintenance of the vegetation.

The trading credits for a wetland treatment system will be divided among site participants as follows:

Wetland costs for installation will be totaled. All parties (i.e., Rahr, LGUs, state and federal offices, private organizations, etc.) contributing to the installation costs and estimation of maintenance costs will determine the percent credits. Operation and research costs provided by third parties will not be calculated in the crediting process.